Center for Independent Experts (CIE) External Independent Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

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1. EXECUTIVE SUMMARY

The Caribbean Red Hind, *Epinephelus guttatus,* is one of most important commercial species in Puerto Rico and USVI. It is characterized by a long lifespan, slow growth, a protogynous hermaphrodite sexual strategy and short-term annual spawning aggregations that make them highly vulnerable to overexploitation. Intensive fishing during the 1970s led to continually decreasing annual catches during the 1980s, resulting in low landings in the 1990s. Numerous studies have reported red hind as an overfished species.

For the purposes of the current Red Hind assessment various sources of fishery-dependent and fishery-independent datasets have been considered. Several of them were characterized as having substantial gaps in the time-series, unknown levels of uncertainty, high variability and low sampling size. As a result there were not included further in the analysis.

The assessment was performed using length frequency data from Puerto Rico and USVI. These were the most temporally consistent sources of species-specific information, thus, were considered the best available Red Hind datasets. The non-equilibrium mean-length estimator approach was undertaken in this assessment to provide estimates of total mortality. A detailed deterministic sensitivity analysis was conducted to evaluate the sensitivity of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. The fishing mortality was estimated using total mortality from the sensitivity analysis and natural mortality based on a maximum-age approach. The assessment methodology followed here provided estimates for total mortality, fishing mortality and Lc. The analysis couldn't provide stock population parameters such as MSY, biomass, abundance, F_{MSY}, B_{MSY}, selectivity etc. To remedy this, F_{msy} proxies (i.e. $F_{30\%}$ and $F_{40\%}$) from yield-per-recruit and spawner-per-recruit analyses were considered. Estimated probabilities of overfishing were respectively: 25% and 40% for Puerto Rico, 42% and 57% for St Thomas and 54% and 66% for St Croix. These probabilities indicated that the Red Hind stock has, on average, a 32.5%–60% risk of experiencing overfishing. The findings were consisted with the increased total mortality estimates for St Thomas, St Croix and Puerto Rico (diving fleet only). It needs to be underlined that the current findings were based on the analysis of TIP datasets only. Due to the limitations of the approach and of the sampling quality/quantity there have been no quantitative estimates of important stock population parameters. Therefore the estimated overfishing probabilities can only be used as indicative of the status of the population. The increasing trend in total mortality estimates can also serve as an indicator of an increased exploitation pattern. An important issue that weakens the reliability of the current estimates and restricts their use to support status inferences is the reported market driven selectivity. This merits further investigation.

A number of recommended actions could be advanced to support the fisheries in the US Caribbean. A first priority could be the promotion of basic fish biology research (e.g. age, growth, diet studies, length/age-at-maturity, fecundity) to provide the fundamental knowledge that will support future assessments. The introduction of fishery-independent surveys in order to provide scientifically sound information and data to support stock assessment, fishery conservation and management is also considered top priority. In order to disclose species' selectivity patterns and improve resource exploitation, gear selectivity studies should be carried out. These gear experiments coupled with discard estimates from the fleet statistics and onboard scientific sampling will help the assessment of discard mortality. It is also imperative to improve the existing fisheries data collection system. The data sampling programme should ideally collect fishery-dependent information in all major fishing ports, villages, landing sites etc. Catches, effort, discards, economic (e.g. costs, profits) and social (e.g. employment, education) information could be collected on site from representative samples of each gear, fleet and fishery. Similar data, especially catches, effort, discards, costs and profits can be collected regularly using onboard sampling, i.e. following fishers during their fishing trips. It is essential that the diverse fisheries datasets are standardized, integrated and comparable in order to be of use to assessment analysis.

Overall, the current findings are considered the best scientific information available.

2. BACKGROUND

The Caribbean Red Hind, *Epinephelus guttatus,* is a commercially important species in Puerto Rico and USVI. It has been targeted mainly after the collapse of *Epinephelus striatus* and yellow-fin grouper (*Mycteroperca venenosa)* spawning aggregations in 1970s and '80s. Red hind contributed 70 to 99% of the total catch of fin fish landed in the Virgin Islands between 1987 and 1992 (Cummings et al. 1997; cited in Nemeth et al 2005). Nemeth et al (2007) reported that by the late 1980s an evaluation of the red hind stock around St. Thomas showed dramatic decreases in average length and an extremely skewed female-to-male sex ratio (15:1) of the spawning population (Beets & Friedlander 1992; ct Nemeth et al 2005) suggesting a disproportional harvest of large males (Sadovy & Figuerola 1992). Other studies also provided evidence that the species was overfished (Sadovy & Figuerola 1992).

The Red Hind is a monadric protogynous hermaphrodite species. It changes sex from female to male at 32–38 cm total length (Sadovy et al. 1992; Nemeth 2005) and reaches maximum length and age at 50–55 cm and 11–22 years (Sadovy et al. 1992). It forms large spawning aggregations from Dec. to Feb. and spawning occurs during the full moon. These spawning aggregations consist of small haremic groups with one male defending three to five females and spawning occurs in pairs 1–2 m above the reef (Shapiro et al. 1993). Sadovy et al. (1994b) found that *E. guttatus* females are determinate spawners and spawn more than once during the course of the annual spawning season. The local fishermen are well aware of this spawning behavior, making the species susceptible to high exploitation rate. As a result the species became an extremely vulnerable target to various gears and fisheries with negative results to its reproduction.

Nemeth et al. (2005) reported that unregulated fishing on aggregations may have contributed to a 65–95% decline of commercial grouper landings in Puerto Rico and Bermuda, respectively (Sadovy and Figuerola 1992; Sadovy et al. 1992; Luckhurst 1996; cited in Nemeth et al. 2005). Less dramatic, but equally important to reproductive output, are the subtle effects of fishing on spawning aggregations of protogynous species such as decreased average fish size, smaller size at sexual transformation and altered male:female sex ratio (Coleman et al. 1996; cited in Nemeth et al. 2005).

The Council implemented in 1985 a Reef Fish FMP to address the decreasing catches of reef species in the US Caribbean. The current FMP of Reef Fish, affecting Red Hind, includes technical measures such as: gear restrictions, seasonal/area closures, catch limits, bag limits, changes to requirements for the constructions of traps. In 1990 the Council introduced Amendment 1 with more stringent management measures to be implemented in the Reef Fish FMP. This was due to continued decreasing trends in species composition and volume of landings, including Red Hind species. A further Amendment 2 was put in place in 1993. In 2005 the Council enacted Amendment 3 to address the required provisions of the Magnuson-Stevens Fishery Conservation and Management Act. The Magnuson-Stevens Act required the Council to redefine the management reference points. The fisheries are to be managed under Annual Catch Limits (ACLs) and accountability measures (AM) that will ensure preventing ACLs from being exceeded. In the absence of MSY estimates, the

Over Fishing Limit (OFL) will use MSY proxy that will be derived from recent average annual landings (Section1_Intro_S35_red_hind).

Puerto Rico's fishery has been monitored through the Fisheries Statistics Project (FSP) continuously since 1967. The project aimed to provide fisheries data for the resources in the waters of Puerto Rico and scientific information to support management plans. Indeed, there are various sources of fishery-dependent and fishery-independent information regarding Red Hind in the Caribbean. Unfortunately, most of them suffer from substantial gaps in time-series, unknown levels of uncertainty, high variability, low sampling size, and misreporting. As a result these fishery datasets are not comparable and cannot be of direct use in the stock assessment process. They can only serve as qualitative indicators. Currently the best available source of Red Hind data to perform a stock assessment in Puerto Rico and USVI is the length frequency data.

3. DESCRIPTION OF REVIEWER’S ROLE IN THE REVIEW ACTIVITIES

Various pre-review preparations were carried out that were deemed necessary in order to conduct the best possible review. Firstly, in early August 2014, three weeks prior to the start of the review process, a number of key publications and material were searched for and downloaded from web databases regarding the Red Hind species in the Caribbean. This included also the CIE web site. Their detailed study enabled the reviewer to get familiar with the species' biology, ecology and fishery in Puerto Rico and USVI.

Secondly, the NMFS Project Contact provided additional background material and reports in advance of the peer review. These included reference documents RD01-09, working papers DW01-04 and AW01 that helped me get acquainted with the characteristics and research carried out so far on the US Caribbean Red Hind.

All three Report Sections provided were subsequently studied thoroughly.

Initially the Report Section_I was read ("Section1_Intro_S35_red_hind") to get an overview of the governance and fishery system that is currently in place in US Caribbean and which the Red Hind fishery follows.

Then the "SectionII_S35_RedHind_DW_Report" was examined. The specific work presented the outcome of the Data Workshop Report where all of the available data sources were reviewed. This enabled understanding the advantages and disadvantages of the available datasets and their suitability (or not) for stock assessment.

Subsequently, the "SectionIII_S35_AW_report" was critically reviewed. The biological parameters, the available datasets, the compilation of input data, the statistics and methods, the equations, the models' configurations and assumptions, the uncertainty, the results, the stock population benchmarks, the proxy values, the overfishing probabilities and recommendations were scrutinized. The strong and weak points of every step of the assessment were evaluated and highlighted. Each ToR was considered and addressed. Additional recommendations and priorities alongside the ones provided by the Assessment workshop were proposed for US Caribbean Red Hind fisheries.

4. SUMMARY OF FINDINGS FOR EACH TOR

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1. Evaluate the data used in the assessment, addressing the following ToRs:

    a) Are data decisions made by the Assessment Workshop sound and robust?

Data review-Commercial landings-Puerto Rico
A number of correction factors have been calculated in order to allow the use of commercial landings. These factors were either coast specific (2003 and afterwards) or single for the entire island (for the period 1983-2002).

The raw data used to calculate the correction factors were available for one year only (2011). These correction factors were subsequently used to all years. This entailed a high degree of uncertainty in the calculation of commercial landings data.

Further, the available information collected during 2011 included species-specific landings for each vessel sampled. The landings' data for all species were pooled; therefore, correction factors were not species specific. The data were further pooled across vessels sampled, sampling dates, and sample sites within coasts.

These datasets, containing species-specific landings details, are quite informative. Developing species-specific correction factors (for example only for species of interest such as the red hind or target species) could have been advantageous for carrying out the red hind assessment. These red hind-specific factors could have produced more precise estimators. Fishing capacity, effective effort and capacity utilization differs between the vessels of a fleet, not to mention within fleets (e.g. vertical line, pots and traps). Fishers' behavior is mainly driven by profit. There are various target species in these fisheries among them of primary interest is red hind.

Pooling all fishing trips, all species landings and all logbook data irrespective of their catch composition results in an overall correction factor for the entire fishery that may well not represent the commercial landings or effort targeted to a specific species of interest, e.g. red hind.

The decisions of the panel to utilize the fishery dependent relative indices of abundance from self-reported fisher logbooks and fishery independent spawning aggregation data as qualitative information are justifiable and robust. Likewise, the panel rightly omitted the spawning aggregation data from St. Croix and Puerto Rico from the current assessment. The decision to exclude the SEAMAP-C data due to the lack of recent year samples and different selectivity was also correct.

    b) Are data uncertainties acknowledged, reported, and within normal or expected levels?

Several concerns have been correctly raised by the DWP with regard to variability and occasionally small sample size of various data sources. These included PR commercial and recreational landings. The issue with the collection of recreational data is also reported: "MRFSS estimates of landings and discards were calculated using catch (or discard) rates from dockside intercepts and total fishing effort from telephone surveys." It is not immediately clear the precision level of the intercepts, how representative these interviews were with regard to the respective fleet/vessels, and how the telephone surveys were conducted (e.g. coverage, questions asked, degree of genuine answers, false reporting etc). As a result evaluating the level of data uncertainties becomes problematic.

Overall the panel has acknowledged most of the data uncertainties.

c) Are data applied properly within the assessment model?

The data have been applied correctly within the chosen assessment model.

d) Are input data series reliable and sufficient to support the assessment approach and findings?

The commercial logbook data of all fishing trips were reported from dates and sites that corresponded to the dockside samples collected. Consequently the logbook data were pooled similarly to the dockside sampling data. Logbook data from vessels that were not sampled were also included in the calculation of correction factors. The coast specific correction factors were calculated as the proportion of reported landings in pounds to observed landings in pounds.

It is often that logbook data suffer from misreporting and false reporting. MRFSS dockside intercepts ideally should have been designed to cover a representative sample of the fishery. Here the total intercepts range was provided, i.e. 1125-3168 per year. This is a highly variable sampling number of intercepts and no explanation is provided with regard to this observed variability. This implies an adaptable sampling protocol rather than a stratified sampling with predetermined and fixed number of samples per gear, fleet, fishery, area, depth zone, month, year. The report supports the opposite: ‘Rate and effort data are stratified by year, wave (two month periods within years, Jan-Feb, Mar-Apr, etc.), mode (private, headboat, shore based fishing), and area (10 miles or less from shore, >10 miles offshore). Landings and discards estimates are calculated within each stratum as: stratum specific landings (or discards) = stratum cpue (or discard rate)*stratum effort.

Fishery dependent relative indices of abundance
Data from self-reported fisher logbooks were examined to characterize abundance trends of Red Hind in Puerto Rico from 1990-2012 (SEDAR35-AW-01). The approach followed here, CPUE calculated on an individual trip basis, is recommended for similar datasets and could have also been utilized on other data sources e.g. commercial landings in PR. These datasets suffer from accuracy issues and the report correctly recommends them as a qualitative index of information only.

Fishery independent data

Spawning aggregation data

There is no sampling either in Feb (since 2010) or in Dec (since 2007) in St. Thomas. Even in January the number of sampling days and transects after 2009 has dramatically declined to reach in 2013: 1 sampling day and 3 transects (Table 1). It would have been beneficial for the assessment if the informative data series up to 2007-2009 continued at the same sampling intensity in recent years. Typically, the quality of the sampling typically improves in terms of sampling intensity in recent years; the opposite trend is observed in St. Thomas. The report attributes that to funding constraints. In St. Croix and Puerto Rico, the sampling intensity (number of surveyed transects) of spawning aggregation visual surveys has remained relatively stable.

As mentioned above, the observed constraints in several of the data series and their quality, compromised their direct input and use in the assessment approach. The TIP data were less problematic and reasonably reliable and sufficient to support the analysis performed.

2. Evaluate the methods used to assess the stock, taking into account the available data.

    a) Are methods scientifically sound and robust?

This is a typical data-limited stock. The length frequency data were the most temporally consistent source of species-specific information. In order to assess the stock, the panel proposed and used the non-equilibrium mean length estimator approach for estimating total mortality and the maximum age approach for estimating natural mortality. The non-equilibrium B-H length based mortality estimator (Gedamke and Hoenig 2006) is an appealing method to deal with length data. It relaxes the assumption of the catch rate being proportional to abundance. Its use is considered appropriate.

There were two positive points for the current analysis: a) the fact that analyses were conducted separately for several island and gear combinations (as shown in Table 7) and b) since the panel realized that there was uncertainty about the growth relationship parameters of red hind, it conducted a sensitivity analysis to evaluate the influence of the growth parameters on the outcome of the mean length estimator and quantify uncertainty in the total mortality estimates.

There are some weak points of the length based mortality estimator as highlighted by Gedamke and Hoenig (2006). Firstly, the method does not make use of the information contained in the variability of length measurements within a year (i.e., the sample variance) thus this is not used in the estimation of mortality rates and change points. That is, under high mortality, there are few large fish and thus the variance in length decreases with increasing mortality rate. An expression for the variance of length measurements as a function of the mortality and growth parameters and the years of change could have been derived and incorporated in the likelihood function as suggested by Gedamke and Hoenig (2006). Secondly, the application of the particular method should consider the possibility of a trend in mean length arising from a particularly large or small year-class. Thirdly, the method assumes constant recruitment over the time series being analyzed. If recruitment varies directly with the stock size, then the model in its current form will underestimate the magnitude of any change in mortality.

    b) Are assessment models configured properly and used consistent with standard practices?

The configuration of the models used annual length-frequency plots for each stratum for the diving, pot and trap, and vertical line fleets from Puerto Rico, St. Croix and pot and trap fleet from St. Thomas. The Lc values chosen for each stratum were presented in Table 7 and Figures 14-16. Relevant information is also presented in Section II: Data Workshop Report. A closer examination of the figures 14-16 reveals that:

a) for Puerto Rico and diving fleet and years 1983, 1984,
b) PR, pot and traps, years 2008, 2010, 2012,
c) St Croix, pot and traps, years 2001, 2003, 2005, 2011,
d) St Croix, vertical line, years 1994-2006,

the annual length frequency distributions, Lc, Mode, were derived from less than 10 specimens of red hind (providing the interpretation is correct). In several of these years the number of lengths measured are 1 or 2. This makes the configuration of the models problematic, as it is difficult for someone to accept a species' annual LFD that is derived from 1 single specimen's measurement. For example in St. Croix vertical line, the Data Workshop Report uses an overall estimate for Lc ~283mm (DWR page 57). It is noted that this peak was driven by the observation from the 1980s and 1990s when sample size was large. This proves that 20 years old data were essentially used in this fleet and extrapolated for the purposes of this assessment. How well do the 20-year old data capture the annual length frequency distribution of the species in recent years, e.g. 2012? How informative could be the Lc and mode used, with regard to the current fishing mortality of the stock? Is Lc of the 1990s similar to the Lc in 2012? Is the fishery exploitation regime comparable? Did any changes in gear selectivity occur? What about technological creep and fishing efficiency? If there have been documented changes in gear selectivity and technological creeping over the last 20 years (more than likely) then the datasets should have been standardized somehow prior to their analysis. Evidently, this raises a number of questions for the adequacy of the model configuration as applied.

On a positive side the assessment models have been used consistent with the international standard practices.

c) Are the methods appropriate for the available data?

The non-equilibrium extension of B-H length based mortality estimator is considered appropriate for the available data. It could have been useful if the analysis has also considered ways to address the weak points of the methodology mentioned in 2a.

The maximum age approach to estimate natural mortality using the regression analysis of Hewitt and Hoenig (2006) is also appropriate for the current data available.

Two fundamental assumptions of the methods used are: a) the red hind growth follows the von Bertalanffy growth model and b) the Sadovy's length-weight relationship (1992) describes adequately the species' growth, as this was considered appropriate to define the mid-level L-W relationship. With regard to a) there is increasing evidence in the literature that the von Bertalanffy GF may not be always the best available to describe the growth of a particular species and should not be used a priori as a panacea. Regarding b) it may have been worth investigating the possibility that the length-weight relationship (among other parameters used, e.g. α_{mat}) may have altered 20+ years after the initial work of Sadovy et al (1992).

3. Evaluate the assessment findings with respect to the following:

   a) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?

The only stock population parameters estimates that were derived from this assessment were the:

a) Total mortality, Z, with the use of the non-equilibrium mean length estimator (and the year of change)
b) Fishing mortality, F, by subtracting from total mortality the natural mortality estimates derived from the maximum-age approach.

Since a number of other stock population parameters could not be extracted from the applied methodology, F_{msy} proxies from yield-per-recruit and spawner-per-recruit analyses were considered.

A substantial part of the model results section was devoted to the analysis of the sensitivity in the estimates of total mortality and in the year of change to changes in the growth parameters and values of Lc. The majority of YPR curves were flat over a wide range of fishing mortality rates. This leads to unrealistically large F_{MAX} estimates. The Panel agreed that the use of F_{MAX} as the F_{MSY} proxy would be inappropriate for this reason. Given that the risk of recruitment overfishing outweighed the risk of growth overfishing and the spatiotemporal closures for Red Hind the use of $F_{30\%}$ and $F_{40\%}$ was considered acceptable.

Puerto Rico
Fishery-independent standardized relative indices of abundance have been developed for the vertical line fishery of the southwest coast of Puerto Rico using the SEAMAP-C data (1991-2011). Initial results indicated that the abundance was declining and that the fishing mortality was increasing, which contradicted the mean length estimator result for the vertical line fleet. The fishery-dependent relative index of abundance that was further developed, i.e. *Scaled Index:* the abundance index scaled to a mean of one over the time series (Figure 2 of S35-DW-04) suggested that abundance remained stable. This particular dataset suffered from a number of issues: A) poor coverage of the last decade. Specifically since 2001, only 2005-06 and 2010-11 were available. B) Its geographic coverage is also restricted to the southwest coast of Puerto Rico. C) It focused on vertical line gear, which represents only a part of the exerted fishing effort and mortality on Red Hind stock by the local fishery (pots and traps, diving).

The AW report results indicated a low probability of Red Hind experiencing overfishing in Puerto Rico. Yet, conflicting trends among the fleets were evident. Pot and traps and vertical line fleets pointed to a decrease in total and fishing mortality. The diving fleet results testified for the opposite, i.e. total mortality remained stable or increased. It is not immediately clear which exploitation pattern is representative of the stock status in terms of abundance and biomass. The panel correctly draws attention to the number of annual reported trips per gear. Pot and traps and vertical line trips have declined dramatically since the early 2000s by 50% and 75% respectively. It is worth noticing that Figure 45 shows several years with all port and traps trips being less (?) than the targeted Red Hind pot and traps trips. In contrast, diving trips increased by approximately 600%. This may imply that the diving fleet may well be more representative of the current stock status as sample size is notably larger in recent years. If that is the case then the per-recruit analyses used to develop overfishing probabilities may have to be adjusted. The reason is that the per-recruit analysis assumed fleets to be an equal representation of the population. This point requires additional research in the future.

Abundance and biomass estimates could also suffer from the omission of the discards component of the catch. The multispecies nature of the reef fisheries inevitable lead to incidental catches of Red Hind during the seasonal closure period.

St Thomas
The main source of data used for the purposes of the current assessment was the pot and trap data. The findings of the present assessment were: 1) the mean length estimator and sensitivity results indicated an increase in total mortality due to a reduction in mean length and 2) the per recruit analysis indicated that the probability of the St. Thomas Red Hind fishery experiencing overfishing was 42% and 57% when using F30% and F40%, respectively.

The lack of eight years of data, especially in late 80s-early 90s and late 90s-early 2000s (Table 4.4.2 of SEDAR 35-Secion II-DWR), had a bearing in the consistency of the reported results.

The panel correctly considered other sources of data but these proved even less informative for Red Hind assessment. For example the maximum density approach to St Thomas spawning aggregation data was characterized by considerable inter-annual variability and lack of clear trend.

An important issue that further undermines the reliability of the current estimates and restricts their use to support status inferences is the reported market driven selectivity. This is usually associated with dome-shaped selectivity, which contradicts the knife-edge selectivity assumption made for Lc. The panel highlights the importance of this matter as it may results in over-estimating fishing mortality.

St Croix
Similarly to the other two areas (Puerto Rico and St Thomas), the mean length estimator and follow up sensitivity analysis gave slightly different results between fleets. More precisely, the mean length estimator and sensitivity results when applied to St. Croix's pot and trap and vertical line fleet length data predicted that the total mortality increased, whereas, the analysis of the diving fleet's length data indicated that total mortality has either remained constant or increased.

The results of the assessment are best seen bearing in mind the limitations of the sampling. Especially, in terms of quality, intensity and sample size of the available datasets. This prevents the current findings from supporting robust status inferences and promoting management decisions. Specifically the majority of the pot and traps and vertical line samples were observed early in the time series. From mid 1990s the number of lengths measured dropped dramatically. In contrast the diving fleet data were from 2002 onwards.

b) Is the stock overfished? What information helps you reach this conclusion?

There is no definite information indicating that the stock is overfished. The AW panel has used a wide range of data sources from various fleets, gears and areas. In several of them there have been signs of overfishing in the past such as the decreased size of Red Hind in pot and trap fishery in St Thomas in 1990-95 and in 2000s.

c) Is the stock undergoing overfishing? What information helps you reach this conclusion?

The results of the per recruit analysis indicated that the stock of Red Hind in Puerto Rico had the lowest probability of overfishing compared to the other USVI species' stocks. The estimated probabilities were 25% and 40% for $F_{30\%}$ and $F_{40\%}$ respectively.

The per recruit analysis indicated that the probability of the St. Thomas Red Hind fishery experiencing overfishing was 42% and 57% when using $F_{30\%}$ and $F_{40\%}$, respectively. Both these probability estimations are relatively high and should be considered.

The St Croix Red Hind per recruit analysis suggested that the species' probability of overfishing was 54% and 66% (shouldn't it be 40% and 56% instead?) of reported values of when using $F_{30\%}$ and $F_{40\%}$, respectively. Both these probability estimations are considerably high and should be followed up closely.

d) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?

The stock recruitment relationship derived from the data analysis was partly informative. As already mentioned, the majority of YPR curves were flat over a wide range of fishing mortality rates, thus unrealistically large F_{MAX} estimates could be generated. However, the distributions and cumulative probabilities presented in Figures 42-44 constituted the aggregated outcomes of the per-recruit analysis and fishing mortality estimates from the sensitivity runs. These distributions and cumulative probabilities enabled the estimates of population benchmarks such as the proxy values of $F_{cur}/F_{30\%}$ and $F_{cur}/F_{40\%}$.

e) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?

The estimated probabilities of overfishing ranged from 25-66% for different proxies and islands. These were based on the analysis of TIP datasets that were considered the best available to perform the mean length estimator approach. Due to the limitations of the approach and of the sampling data quality/quantity there have been no quantitative estimates of important stock population parameters such as abundance, biomass, fishing mortality etc. The overfishing probabilities can only be used as early indicators of the status of the population. The increasing trend in total mortality estimates can also serve as indicator of an increased exploitation pattern.

A limited dataset ana1ysis using scuba diver assessments and covering the period 1999-2004 and only the Red Hind Bank MCD (in St Thomas) provided early indications for recovery. More precisely, the work from Nemeth et al (2005; 2007) used as indicators the average size of Red Hind and the maximum male size. When compared with their respective values before the permanent closure, the average size of red hind increased during the seasonal closure period (10 cm over 12 yr). The maximum total length of male red hind increased by nearly 7 cm following permanent closure. The scientists also reported that average density and biomass of spawning red hind increased by over 60% following permanent closure whereas maximum spawning density more than doubled.

4. Evaluate the stock projections, addressing the following:
    a) Are the methods consistent with accepted practices and available data?
    b) Are the methods appropriate for the assessment model and outputs?
    c) Are the results informative and robust, and useful to support inferences of probable future conditions?
    d) Are key uncertainties acknowledged, discussed, and reflected in the projection results?

According to S35_AW report, ToR no 9, page 7 it is clearly stated that:

"Due to the limited data available, a data poor methodology was attempted that does not include projections of stock dynamics. Therefore, projections were not conducted for this assessment".

5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

An important part of the current assessment report has been devoted to evaluating the sensitivity of and the uncertainty in the estimates of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. These estimated uncertainties were carried further, in the yield per recruit analysis and thus, were embedded in the estimates of the F_{MSY} proxies. This is considered a strong point of the work. So are the clear statements of the implications of the studied uncertainties to the conclusions of this study.

The sensitivity analysis was performed separately for each stratum. The linear model fitted to the four published estimates of von Bertalanffy growth parameters was subsequently used to generate nine additional pairs of K and $L\infty$. These were essential in order to perform the follow up sensitivity analysis. One point here is that the fit of the linear model was marginally adequate (R^2=0.5608). This should have been discussed as well as its likely effect on the sensitivity analysis of the uncertainty of the growth parameters, especially since the sensitivity pairs of asymptotic length and von Bertalanffy growth coefficient were used further in the per-recruit analysis.

Typically, there are six types of uncertainty related to sources of risk in a fisheries setting: those associated with process, observation, model, estimation, implementation and institutions (see Francis & Shotton, 1997). Briefly, *process* uncertainty is defined as the underlying stochasticity in the population dynamics such as the variability in recruitment. *Observation* uncertainty originates from the process of data collection (e.g. inadequate data collection systems and deliberate misreporting), through measurement and sampling error (as we observe a sample and not the entire population). *Model* uncertainty is due to the lack of complete information on the population and community dynamics of the system. Usually fisheries' scientists and managers use mathematical models, i.e. a conceptual set of equations describing (or at least attempts to) how populations and fisheries change over time. Lack of information in building such models causes: a) structural uncertainty (e.g. shape of Stock/Recruit relationship), b) parameter (e.g. is Natural Mortality M 0.2 or 0.3) uncertainty, and c) error structure uncertainty. *Estimation* uncertainty is linked with the process of parameter estimation (that requires data and model) and as such is derived from some or all of the three above types. *Implementation* uncertainty refers to the extent of successful implementation of management policies. *Institutional* uncertainty relates to problematic interaction of interested parties (scientists, fishers, economists, etc.) composing the management process (Francis & Shotton, 1997).

The last two types of uncertainty, i.e. implementation and institutional, are of no immediate interest to any assessment working group. However, the first four types of uncertainty could have a direct impact in any species assessment, here the Red Hind Assessment. Stochasticity in the populations dynamics such as the variability in recruitment, observation uncertainty due to problematic data collection programmes (observed here), model uncertainty (e.g. uncertainty in the Y/R shape), or uncertainty in parameter estimates (here only uncertainty in the growth parameters was considered) e.g. uncertainty in natural mortality or maturity-at-age or vulnerability-at-age values are only few of the forms of uncertainty that someone could have additionally considered.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.

- Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
- Provide recommendations on possible ways to improve the SEDAR process.

All research recommendations made by the AW panel are appropriate and in the right direction.

The AW panel concluded that in the near future the mean length estimator will continue to form the basic methodology for US Caribbean stock assessments. They also recommended that effort should be directed to basic fish biology research (e.g. age, growth, diet studies, length/age-at-maturity, fecundity) to provide the knowledge that will support future assessments. This is, and must be, indeed the top priority for key species. Even if these research priority areas cannot be covered within available financial resources from fisheries or public authorities, a carefully designed university programme can help on this direction. For example, a number of relevant research topics can be advanced for M.Sc or PhD dissertations and these will provide, with minimum cost and in a short period, the missing biological information.

Fishery-independent surveys were also recommended as a top research priority. Such surveys should be carefully designed and cover the entire distribution of the key species in all three studied regions, i.e. Puerto Rico, St Thomas/St John and St Croix. A rigorous sampling programme should be put in place, preferably using the same vessel(s) and gear specifications. Alternatively similar vessels/gears can be used providing that these should be standardized at some stage. This will allow for direct and meaningful comparisons to be made.

Sampling should allow for a sufficient number of samples to be taken in and out of closed areas, fishing grounds, spawning and nursery grounds. Samples should include not only catches and discards of key species but also fish biology (length, weight, age, diet, reproductive), oceanographic (temperature and salinity profiles) and seabed substrate data.

Selectivity experiments using commercial gear can also assist in disclosing species' selectivity patterns. This coupled with discard estimates from the fishery will allow the assessment of discard mortality.

In the specific fishery a substantial lack of key biological parameters is obvious. Guidelines for filling these gaps have been provided earlier. At the same time it is evident that various sources of fishery-dependent information is available. Some of these datasets are short, others are longer, a few have yearly gaps, a number of them are recent, and several are older. All these indicate what is common in fisheries all over the world: rigorous (and therefore expensive) fisheries sampling programmes were seldom the priority. Yet, there is information in these datasets and the AW panel had tried to use this.

The existing data collection programme should be improved. Following standard and common sampling protocols for all isles, fleets, gears, seasons and strata. This sampling programme should collect fishery-dependent info in all major fishing ports, villages, landing sites etc. Catches, effort, discards, economic (e.g. costs, profits), social (number of fishers, sex, education etc) information could be collected on site from representative samples of each gear and fishery. Similar data, especially catches, effort, discards, costs and profits, can be collected regularly using onboard sampling, i.e. following the fishers during their fishing trips. This will provide more realistic data that could then be integrated and compared with port sampling, intercepts, TIP, logbooks. For example self-reported logbooks or TIPs usually suffer from misreporting and false reporting. Such a data collection framework programme will shortly result in datasets that will allow for meaningful inferences to be made also utilizing the past data.

Expert local ecological knowledge, participatory stakeholders' involvement, use of already available datasets such as those explored here and even spatial back filling (imputing) of missing catches may all aid to this end.

I have no remarks with regard to the SEDAR process as it is well-organized and efficient.

7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.

According to section I page 14: 'The Council implemented Amendment 3 to the Reef Fish FMP (CFMC 2005) in 2005 to address required provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Caribbean SFA Amendment).' Among the measures that the Council implemented were management reference points that rely on recent average catch. Recently there has been growing interest in the use of methods for estimating overfishing thresholds and setting catch limits for stocks with limited data. The so-called catch-based methods have generally been employed where insufficient data exist for determining an OFL using more sophisticated methods (Carruthers et al 2014).

The Red Hind fishery dependent data available suffered from limitations (e.g. landings only) and unknown accuracy. Still it would be interesting to apply any of the proposed catch-based methods to obtain management reference points such as OFL, ABC, ACL, OY and F_{MSY} and compare these with those derived from the present analysis. Obviously, there may be considerable uncertainty regarding the inputs to the methods. Adding appropriate error components could simulate the imperfect knowledge of these quantities. Another avenue of research could be to use these early datasets as priors for a Bayesian approach as new data are collected.

A minor technicality: it was difficult, in places, to follow up all the different datasets in DW and AW, especially which ones were finally used for the full assessment, which ones were only qualitatively used and which ones were not considered. A simple table with the various data sources which show the advantages, disadvantages and importantly their level of use (or not) would have greatly facilitated the review process.

5. CONCLUSIONS

There are various sources of fishery-dependent and fishery-independent information regarding Red Hind in the Caribbean. Most of them suffer from substantial gaps in the time-series, unknown levels of uncertainty, high variability, low sampling size, and misreporting. As a result they cannot be of direct use to the stock assessment process but only serve as qualitative indicators.

Currently the best available source of Red Hind data to perform a stock assessment in Puerto Rico and USVI is the length frequency data. The non-equilibrium mean-length estimator approach was undertaken in this assessment to provide estimates of total mortality. A detailed deterministic sensitivity analysis was conducted to evaluate the sensitivity of total mortality to the von Bertalanffy growth parameters and the choice of length at recruitment to the fishery. Then the fishing mortality was estimated using total mortality from the sensitivity analysis and natural mortality based on a maximum-age approach. The assessment methodology followed here provided estimates for total mortality, fishing mortality and Lc. On a negative side it couldn't deliver stock population parameters such as MSY, biomass, abundance, F_{MSY}, B_{MSY}, selectivity etc. These parameters could have been used as reference points and population benchmarks and thus facilitate buy-in of scientific advice in support to policy.

In order to clarify whether Red hind was experiencing overfishing, estimates of fishing mortality were compared to F_{MSY} proxies from yield-per-recruit and spawner-per-recruit analyses namely $F_{30\%}$ and $F_{40\%}$. Probabilities of overfishing were provided for $F_{30\%}$ and $F_{40\%}$ respectively: 25% and 40% for Puerto Rico, 42% and 57% for St Thomas and 54% and 66% for St Croix. These probabilities and their associated risk indicate that the Red Hind stock has, on average, a 32.5%–60% risk of experiencing overfishing and therefore is being exploited unsustainably. Such a high fishing pressure upon larger males within aggregations has been suggested to result in sperm limitation and unbalanced male:female ratio. These findings are in agreement with estimated increases in total mortality for St Thomas and St Croix. In Puerto Rico the trend in total mortality was unclear: pot, traps and vertical line fleets exhibited decreasing total mortality whereas the diving fleet increasing Z values. However, in Puerto Rico there was an issue with sampling intensity in recent years and representative sampling of the population. Evidently, stringent harvest control management procedures, including more effective monitoring, surveillance and enforcement, will be required to return the stock to sustainable levels of exploitation. Future management procedures should be designed to lower the risk of high harvest rates and to promote stock recovery when stock size is low, thus reducing the risk of over exploitation.

When someone considers the results of this assessment, the person should always take into account the limitations of the sampling scheme. Only the TIP data were used for this assessment. Various other data sources existed but were not fully used due to various shortcomings. Evidently there is an issue with regard to how well the TIP data are representing the population. A key aspect in model development that is related to sampling error is that of representative sampling. This is because even if the particular model applied here fitted the present data set, this does not necessarily imply that the model also described adequately the entire Red Hind population. This restricts the current findings from supporting status inferences and promoting management decisions. Still total mortality estimates, Lc and overfishing probabilities can be utilized as early indicators of stock status.

6. RECOMMENDATIONS

The following are some general suggestions and recommendations to improve the current status of the fishery.

A. Improve the fishery information management system. The Puerto Rico's fishery has been monitored through the Fisheries Statistics Project (FSP) continuously since 1967. The project aimed to provide fisheries data for the resources in the waters of Puerto Rico and scientific information to support management plans. Despite this FSP initiative, the lack of reliable official fishery statistics is evident and constitutes a considerable handicap for the assessments. It is important to improve the official state authority design, implementation and integration of the system to collect and compile statistical data from the entire national fisheries. This data collection system should ideally cooperate with other authorities e.g. the port authorities, the local customs offices, correspondents in municipalities and communities, villages. The primary objective should be to collect fishery-dependent info: catch, effort, discards, fleet, economic (cost, profit), social (e.g. employment, education) statistics. Following standard and common sampling protocols for all isles, fleets, gears, seasons and strata. Similar data, especially catches, effort, discards, costs and profits, can be collected regularly using onboard sampling, i.e. following the fishers during their fishing trips. This will provide more realistic data that could then be compared with port sampling, intercepts, TIP, logbooks.

B. Basic research could be promoted to study Red Hind biological parameters. This research preferably may include: age, growth, feeding, length/age-at-maturity, and fecundity to provide the fundamental knowledge that will support future assessments.

C. Fishery-independent surveys should be carefully designed and carried out in order to provide scientifically sound information and data to support stock assessment, fishery conservation and management. These ideally should cover the distribution of key species (including Red Hind) in all three studied regions, i.e. Puerto Rico, St Thomas/St John and St Croix. Such scientific surveys will provide abundance and biomass estimates but also additional size distribution, maturity, spawning season and areas, scales or otoliths for age and growth studies, stomach contents, fecundity information and they can target early-life stages and adult parts of the population. In addition a number of auxiliary data can be collected, e.g., oceanographic, seabed substrate, information on essential fish habitat of the species. These fishery-independent surveys will provide complete catch records in the area. Commercial vessels often discard many species and especially small fish (< MLS: minimum landing size), whereas research vessel surveys can provide information on the total species composition and size range available to the gear. The scientific information and data that will be collected will increase long-term economic and social benefits from the fisheries resources in the area. Once established, these surveys should be carried out routinely to support scientific monitoring of the living marine resources (e.g. annually or bi-annually).

D. Following the required provisions of the Magnuson-Stevens Fishery Conservation and Management Act, a number of management reference points for species undergoing overfishing were established by the 2010 Caribbean Annual Catch Limit Amendment 3. The Annual Catch Limit (ACL) is currently the main management tool and US fisheries should aim to specify ACLs and accountability measures, AMs, to prevent ACLs from being exceeded. Fishery-dependent catch, effort and discards statistics are urgently required to follow these provisions. As a first step, catch-based methods can be implemented that require only catch information. Biomass dynamic models can also be applied providing catch and effort data will become available. However, scientific advice to fishery managers needs to be expressed in probabilistic terms to convey uncertainty about the consequences of alternative harvesting policies. One avenue for future stock assessment could be to build informative prior probability distributions (*priors*) for *r, K, q, M, F*. Expert knowledge and the available fishery datasets may prove useful in building such priors. Then using a simple biomass dynamic model fitted to catch rate data, a risk assessment approach can be applied to evaluate the potential consequences of alternative ACLs. The benefit for the fishery from a probabilistic modelling method would be that uncertainties would have been considered but also estimates of biological risks of alternative ACL-policy options will be provided. This may serve as a basis for providing precautionary fishery management advice given the high degree of uncertainty.

E. Design and carry out gear selectivity studies aiming to disclose species' selectivity patterns and improve resource exploitation. This coupled with discard estimates from the fleet statistics and onboard scientific sampling will allow the assessment of discard mortality.

F. Improve the effectiveness of external partnerships with fishers, managers, scientists, conservationists, and other interested groups to build a balanced approach to meet common fisheries goals. This will ensure best buy-in of any future management measure.

G. Enforce stringent monitoring, control and surveillance mechanisms to restrict unregulated fishing in spawning aggregations that restrain stock recovery.

APPENDIX 1: BIBLIOGRAPHY OF MATERIALS PROVIDED FOR REVIEW

SEDAR35-DW-01 Monitoring of Commercially Exploited Fisheries Resources in Puerto Rico
SEDAR35-DW-02 Reef Fish Monitoring
SEDAR35-DW-03 Red hind data from Puerto Rico
SEDAR35-DW-04 Abundance Indices of Red Hind Collected in Caribbean SEAMAP Surveys from Southwest Puerto Rico

SEDAR35-AW-01 Standardized Catch Rates for Red Hind from the Commercial Diving, Trap, and Vertical Line Fisheries in Puerto Rico

SEDAR35-RD01 A Cooperative Multiagency Reef Fish Monitoring Protocol for the U.S. Virgin Islands Coral Reef Ecosystem, v. 1.00
SEDAR35-RD02 Fishery independent survey of commercially exploited fish and shellfish populations from mesophotic reefs within the Puerto Rican EEZ
SEDAR35-RD03 Portrait of the commercial fishery of red hind, Epinephelus guttatus, in Puerto Rico during 1992-1999
SEDAR35-RD04 Portrait of the commercial fishery of red hind, Epinephelus guttatus, in Puerto Rico during 1988-2001
SEDAR35-RD05 Evaluation of seasonal closures of red hind, Epinephelus guttatus (Pisces: Serranidae), spawning aggregations to fishing off the west coast of Puerto Rico, using fishery-dependent and independent time series data
SEDAR35-RD06 Description of larval development of the red hind Epinephelus guttatus, and the spatio-temporal distributions of ichthyoplankton during a red hind spawning aggregations off La Parguera, Puerto Rico
SEDAR35-RD07 Brief Summary of SEAMAP Data Collected in the Caribbean Sea from 1975 to 2002
SEDAR35-RD08 Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection
SEDAR35-RD09 Spatial and temporal patterns of movement and migration at spawning aggregations of red hind, Epinephelus guttatus, in the U.S. Virgin Islands

Section1_Intro_S35_red_hind
SectionII_S35_RedHind_DW_Report_with_disclaimer_watermark
SectionIII_S35_AW_report_with_watermark

Additional bibliography used for the review:

Beets J, Friedlander A. 1992. Stock analysis and management strategies for red hind, *Epinephelus guttatus*, in the U.S. V. I. Proc 42nd Gulf Caribb Fish Inst 42: 66–79.

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Sadovy Y, Figuerola M. 1992. The status of red hind fishery in Puerto Rico and St. Thomas, as determined by yield-per-recruit analysis. Gulf Caribb Fish Inst 42: 23–38.

Sadovy Y, Figuerola M, Roman A. 1992. Age and growth of red hind *Epinephelus guttatus* in Puerto Rico and St. Thomas. Fishery Bulletin 90: 516–528.

Sadovy, Y., A. Rosario, and A. Roman. 1994. Reproduction in an aggregating grouper, the red hind, *Epinephelus guttatus*. Environmental Biology of Fishes 41: 269-286.

Shapiro DY, Sadovy Y, McGehee MA (1993) Size, composition, and spatial structure of the annual spawning aggregation of the red hind, *Epinephelus guttatus* (Pisces: Serranidae). Copeia 2:399–406

APPENDIX 2: A COPY OF THE CIE STATEMENT OF WORK

Statement of Work for Dr. Christos Maravelias

External Independent Peer Review by the Center for Independent Experts

SEDAR 35 Caribbean Red Hind Assessment Desk Review

Scope of Work and CIE Process: The National Marine Fisheries Service's (NMFS) Office of Science and Technology coordinates and manages a contract providing external expertise through the Center for Independent Experts (CIE) to conduct independent peer reviews of NMFS scientific projects. The Statement of Work (SoW) described herein was established by the NMFS Project Contact and Contracting Officer's Technical Representative (COTR), and reviewed by CIE for compliance with their policy for providing independent expertise that can provide impartial and independent peer review without conflicts of interest. CIE reviewers are selected by the CIE Steering Committee and CIE Coordination Team to conduct the independent peer review of NMFS science in compliance the predetermined Terms of Reference (ToRs) of the peer review. Each CIE reviewer is contracted to deliver an independent peer review report to be approved by the CIE Steering Committee and the report is to be formatted with content requirements as specified in **Annex 1**. This SoW describes the work tasks and deliverables of the CIE reviewer for conducting an independent peer review of the following NMFS project. Further information on the CIE process can be obtained from www.ciereviews.org.

Project Description: SEDAR 35 will be a compilation of data, benchmark assessments of the stocks, and an assessment review conducted for Caribbean red hind. The review is responsible for ensuring that the best possible assessment is provided through the SEDAR process and will provide guidance to the SEFSC to aid in their review and determination of best available science, and when determining if the assessment is useful for management. The stocks assessed through SEDAR 35 are within the jurisdiction of the Caribbean Fishery Management Council and the territorial waters of Puerto Rico and the U.S. Virgin Islands. The Terms of Reference (ToRs) of the peer review are attached in **Annex 2**.

Requirements for CIE Reviewers: Three CIE reviewers shall conduct an impartial and independent peer review in accordance with the SoW and ToRs herein. CIE reviewers shall have working knowledge and recent experience in the application of The CIE reviewers shall have expertise in stock assessment, statistics, fisheries science, and marine biology sufficient to complete the tasks of the scientific peer-review described herein. Experience with data-limited assessment methods is desirable. Each CIE reviewer's duties shall not exceed a maximum of 10 days to complete all work tasks of the peer review described herein.

Location of Peer Review: Each CIE reviewer shall conduct an independent peer review as a desk review, therefore no travel is required.

Statement of Tasks: Each CIE reviewer shall complete the following tasks in accordance with the SoW and Schedule of Milestones and Deliverables herein.

Prior to the Peer Review: Upon completion of the CIE reviewer selection by the CIE Steering Committee, the CIE shall provide the CIE reviewer information (full name, title, affiliation, country, address, email) to the COTR, who forwards this information to the NMFS Project Contact no later the date specified in the Schedule of Milestones and Deliverables. The CIE is responsible for providing the SoW and ToRs to the CIE reviewers. The NMFS Project Contact is responsible for providing the CIE reviewers with the background documents, reports, and other pertinent information. Any changes to the SoW or ToRs must be made through the COTR prior to the commencement of the peer review.

Pre-review Background Documents: Two weeks before the peer review, the NMFS Project Contact will send (by electronic mail or make available at an FTP site) to the CIE reviewers the necessary background information and reports for the peer review. In the case where the documents need to be mailed, the NMFS Project Contact will consult with the CIE Lead Coordinator on where to send documents. CIE reviewers are responsible only for the pre-review documents that are delivered to the reviewer in accordance to the SoW scheduled deadlines specified herein. The CIE reviewers shall read all documents in preparation for the peer review.

Desk Review: Each CIE reviewer shall conduct the independent peer review in accordance with the SoW and ToRs, and shall not serve in any other role unless specified herein. **Modifications to the SoW and ToRs cannot be made during the peer review, and any SoW or ToRs modifications prior to the peer review shall be approved by the COTR and CIE Lead Coordinator.** The CIE Lead Coordinator can contact the Project Contact to confirm any peer review arrangements.

Contract Deliverables - Independent CIE Peer Review Reports: Each CIE reviewer shall complete an independent peer review report in accordance with the SoW. Each CIE reviewer shall complete the independent peer review according to required format and content as described in Annex 1. Each CIE reviewer shall complete the independent peer review addressing each ToR as described in Annex 2.

Specific Tasks for CIE Reviewers: The following chronological list of tasks shall be completed by each CIE reviewer in a timely manner as specified in the **Schedule of Milestones and Deliverables**.

1) Conduct necessary pre-review preparations, including the review of background material and reports provided by the NMFS Project Contact in advance of the peer review.
2) Conduct an independent peer review in accordance with the ToRs (**Annex 2**).
3) No later than September 12, 2014, each CIE reviewer shall submit an independent peer review report addressed to the "Center for Independent Experts," and sent to Dr. Manoj Shivlani, CIE Lead Coordinator, via email to shivlanim@bellsouth.net, and Dr. David Sampson, CIE Regional Coordinator, via email to david.sampson@oregonstate.edu. Each CIE report shall be

written using the format and content requirements specified in Annex 1, and address each ToR in **Annex 2**.

Schedule of Milestones and Deliverables: CIE shall complete the tasks and deliverables described in this SoW in accordance with the following schedule.

4 August 2014	CIE sends reviewer contact information to the COTR, who then sends this to the NMFS Project Contact
18 August 2014	NMFS Project Contact sends the CIE Reviewers the report and background documents
25 August through 12 September 2014	Each reviewer conducts an independent peer review as a desk review
12 September 2014	CIE reviewers submit draft CIE independent peer review reports to the CIE Lead Coordinator and CIE Regional Coordinator
26 September 2014	CIE submits the CIE independent peer review reports to the COTR
30 September 2014	The COTR distributes the final CIE reports to the NMFS Project Contact and regional Center Director

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

Modifications to the Statement of Work: This 'Time and Materials' task order may require an update or modification due to possible changes to the terms of reference or schedule of milestones resulting from the fishery management decision process of the NOAA Leadership, Fishery Management Council, and Council's SSC advisory committee. A request to modify this SoW must be approved by the Contracting

Officer at least 15 working days prior to making any permanent changes. The Contracting Officer will notify the COTR within 10 working days after receipt of all required information of the decision on changes. The COTR can approve changes to the milestone dates, list of pre-review documents, and ToRs within the SoW as long as the role and ability of the CIE reviewers to complete the deliverable in accordance with the SoW is not adversely impacted. The SoW and ToRs shall not be changed once the peer review has begun.

Acceptance of Deliverables: Upon review and acceptance of the CIE independent peer review reports by the CIE Lead Coordinator, Regional Coordinator, and Steering Committee, these reports shall be sent to the COTR for final approval as contract deliverables based on compliance with the SoW and ToRs. As specified in the Schedule of Milestones and Deliverables, the CIE shall send via e-mail the contract deliverables (CIE independent peer review reports) to the COTR (William Michaels, via William.Michaels@noaa.gov).

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Annex 1: Format and Contents of CIE Independent Peer Review Report

1. The CIE independent report shall be prefaced with an Executive Summary providing a concise summary of the findings and recommendations, and specify whether the science reviewed is the best scientific information available.

2. The main body of the reviewer report shall consist of a Background, Description of the Individual Reviewer's Role in the Review Activities, Summary of Findings for each ToR in which the weaknesses and strengths are described, and Conclusions and Recommendations in accordance with the ToRs.

3. The reviewer report shall include the following appendices:

   Appendix 1: Bibliography of materials provided for review
   Appendix 2: A copy of the CIE Statement of Work

Annex 2: Terms of Reference for the Peer Review

SEDAR 35 Caribbean Red Hind Assessment Desk Review

1. Evaluate the data used in the assessment, addressing the following:
   e) Are data decisions made by the Assessment Workshop sound and robust?
   f) Are data uncertainties acknowledged, reported, and within normal or expected levels?
   g) Are data applied properly within the assessment model?
   h) Are input data series reliable and sufficient to support the assessment approach and findings?
2. Evaluate the methods used to assess the stock, taking into account the available data.
   d) Are methods scientifically sound and robust?
   e) Are assessment models configured properly and used consistent with standard practices?
   f) Are the methods appropriate for the available data?
3. Evaluate the assessment findings with respect to the following:
   f) Are abundance, exploitation, and biomass estimates reliable, consistent with input data and population biological characteristics, and useful to support status inferences?
   g) Is the stock overfished? What information helps you reach this conclusion?
   h) Is the stock undergoing overfishing? What information helps you reach this conclusion?
   i) Is there an informative stock recruitment relationship? Is the stock recruitment curve reliable and useful for evaluation of productivity and future stock conditions?
   j) Are the quantitative estimates of the status determination criteria for this stock reliable? If not, are there other indicators that may be used to inform managers about stock trends and conditions?
4. Evaluate the stock projections, addressing the following:
   e) Are the methods consistent with accepted practices and available data?
   f) Are the methods appropriate for the assessment model and outputs?
   g) Are the results informative and robust, and useful to support inferences of probable future conditions?
   h) Are key uncertainties acknowledged, discussed, and reflected in the projection results ?
5. Consider how uncertainties in the assessment, and their potential consequences, are addressed.

- Comment on the degree to which methods used to evaluate uncertainty reflect and capture the significant sources of uncertainty in the population, data sources, and assessment methods
- Ensure that the implications of uncertainty in technical conclusions are clearly stated.

6. Consider the research recommendations provided by the Assessment workshop and make any additional recommendations or prioritizations warranted.
    - Clearly denote research and monitoring that could improve the reliability of, and information provided by, future assessments.
    - Provide recommendations on possible ways to improve the SEDAR process.
7. Provide guidance on key improvements in data or modeling approaches which should be considered when scheduling the next assessment.